

# Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/GB05/000892

International filing date: 09 March 2005 (09.03.2005)

Document type: Certified copy of priority document

Document details: Country/Office: GB  
Number: 0405530.7  
Filing date: 12 March 2004 (12.03.2004)

Date of receipt at the International Bureau: 09 May 2005 (09.05.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



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The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

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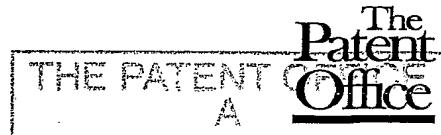
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The Patent Office

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1. Your reference

PA 5094

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0405530.7

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

University College London

Gower Street  
London  
WC1E 4BT  
United KingdomPatents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

798652012

4. Title of the invention

Prosthetic Limb Attachment

5. Name of your agent (*if you have one*)

Marks &amp; Clerk

45 Grosvenor Road  
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Number of earlier application

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Description 8

Claim(s) 3

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Abstract 1

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Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

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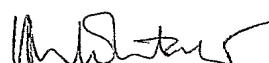
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11.

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Date

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12. Name and daytime telephone number of person to contact in the United Kingdom

Iain Whitaker

01727 854215

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## Prosthetic Limb Attachment

### Field of the Invention

5 The present invention concerns improvements in and relating to prosthetic limb attachment.

### Background to the Invention

10 In recent years procedures have been developed in which a limb prosthesis (artificial arm or leg) is attached by a bone implant directly to the bone of an amputee's residual limb. As an example of such a procedure, the present applicant's own UK patent application GB-A-2,365,355 describes and illustrates the use of an intra-osseous transcutaneous implant that is secured at a distal end to a  
15 limb prosthesis or severed limb and that attaches at a proximal end directly to the bone of the patient's residual limb through the skin. The implant is differentially surface treated, having coatings (e.g. of hydroxyapatite and/or a protein such as laminin or fibronectin to encourage fibrous in-growth) at its proximal end to promote optimal integration with the bone, ligament and skin tissues of the residual limb while  
20 having a very low surface energy at its distal (external) end deterring bacterial colonisation at the implant's external skin interface.

The transcutaneous bone implants of GB-A-2,365,355 are relatively securely held in place to the patient's native tissue and are less prone to infection than prior  
25 transcutaneous implants. However, in use of these or other direct bone implants for attachment, the attachment can still pose mechanical problems in use. In particular, the joint of the prosthesis to the bone generally has no give and there is a substantial risk that a bending or torsional force applied to the prosthetic limb may either break the bone or cause the bone implant to become detached from it.

30

The present invention seeks, amongst other objectives, to provide means for addressing the shortcomings of the existing attachments and the bone implant differential coating technology of GB-A-2,365,355 suitably is used in combination with the present invention.

## **Summary of the Invention**

According to a first aspect of the present invention there is provided an apparatus  
5 for attaching a prosthetic limb to the bone of a patient, the apparatus comprising:

10

- i) a proximal component to mount to a bone implant ;
- ii) a distal component to mount to a prosthetic limb ; and
- iii) a coupling body coupling together the proximal and distal components with freedom to articulate when, in use, a bending and/ or torsional force is applied to the prosthetic limb only when the force exceeds a threshold level whereby the force may be accommodated by articulation within the attachment apparatus.

15 The attachment apparatus thus functions as a fail-safe articulation mechanism protecting the bone of the patient. Suitably it is first attached to the bone implant component and then has the prosthetic limb attached to it. However, it may be incorporated into the bone implant component or the prosthetic limb and may be, in part or wholly, integrally formed or assembled with the bone implant or the limb prosthesis.

20 Preferably the coupling body has a clutch mechanism to rotationally couple the prosthetic limb to the bone implant in use but which automatically disengages, rotationally decoupling the prosthetic limb from the bone implant, when torque applied to the prosthetic limb exceeds a predetermined threshold.

25 The apparatus suitably has a resilient biasing means whereby the clutch mechanism  
is resiliently biased to the rotationally coupled state and whereof the biasing force  
applied to the clutch mechanism by the resilient biasing means in use determines  
the threshold level of torque on the prosthetic limb that will cause disengagement of  
30 the clutch mechanism.

Preferably the apparatus has adjustment means whereby the threshold level of torque on the prosthetic limb that will cause disengagement of the clutch mechanism may be increased or decreased. In the case that the apparatus has the aforesaid resilient biasing means, the adjustment means may comprise a screw adjustment

means that suitably is screw-threadedly adjustable axially toward or away from the clutch mechanism.

Preferably the clutch mechanism has opposing sets of co-operating clutch teeth 5 whereof the teeth are substantially symmetrical in profile whereby the clutch mechanism may be disengaged in either rotational direction of torque, clock-wise or anti-clockwise, applied to the prosthetic limb.

Suitably the clutch mechanism is on the proximal component. This is particularly 10 useful when used in tandem with an automatically disengageable connector to allow tilting, since it will remain effectively operable even when the tilting connector is actuated to tilt. Preferably it is configured to be located external to the patient's skin in use so that there will be no tearing of the patient's skin when the clutch mechanism disengages.

15 Preferably the coupling body has an automatically disengageable connector that couples together the proximal and distal components so that one is in a fixed angle relation to the other (e.g. axially aligned with or at a fixed angle of incline to the axis of the other) in normal use but with freedom to articulate away from the fixed angle 20 relation when, in use, a bending force is applied to the prosthetic limb only when the force exceeds a threshold level.

25 The apparatus with disengageable connector suitably has a resilient biasing means whereby the disengageable connector is resiliently biased to the coupled state and whereof the biasing force applied to the disengageable connector by the resilient biasing means in use determines the threshold level of bending force on the prosthetic limb that will cause disengagement of the disengageable connector.

30 Preferably the disengageable connector comprises a pin mounted to one of the proximal and distal components and co-operating with a socket in the other of the proximal and distal components. Suitably the pin is mounted to be movable back and forth axially of the component to which it is mounted and biased forwardly. Preferably the pin is concentrically mounted within the component.

Preferably the pin has a domed (e.g. ball-shaped) or pointed tip and the socket is of a corresponding concave shape whereby a bending force applied to the prosthetic limb in use will cause the tip of the pin to ride outwardly up the socket wall.

5 Suitably the shape of the tip is domed or substantially conical to facilitate disengagement of the disengageable connector whichever radial orientation the bending force is applied from. Preferably such an arrangement is combined with the disengageable connector being configured to allow universal articulation, substantially in the manner of a ball joint, when it disengages.

10

In one preferred embodiment the disengageable connector comprises a T-shaped formation at the end of one or both of the proximal and distal components that are adjacent each other, the head of the or each T-shaped formation being curved/arcuate to facilitate tilting of one component relative to the other. Suitably the T-shaped formations substantially nest one against the other and suitably they are accommodated in the coupling body or a further coupling body, to tilt within the coupling body. Amongst special benefits from the use of a disengageable connector of this type in contrast to, say, a ball-in-socket connector, is that the fulcrum about which the distal component tilts is better distanced from the bone implant, further reducing risk of trauma to that area.

20

Preferably the coupling body has slots therethrough, through each of which a respective end of a head of a T-shaped formation extends and whereby the end may protrude to a greater or lesser extent as the component tilts, whereby the coupling body provides a captive articulated joint with a restricted degree of tilting freedom of movement.

25

Suitably one T-shaped formation is oriented in the coupling body with its head substantially orthogonal to the head of the other, whereby through tilting of each relative to the other an approximately universal or gyrating articulation may be achieved.

Brief Description of the Drawings

A preferred embodiment of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings,  
5 wherein :

Figure 1 is a schematic perspective view of the attachment apparatus of the preferred embodiment;

10 Figure 2 is a view similar to Figure 1 but with a clutch mechanism part omitted to show the parts of the attachment responsible for bending articulation;

Figure 3 is a view similar to Figure 2 but with a connector body of the attachment removed to show the co-operating ends of the proximal and distal components and  
15 15 how they may move relative to each other;

Figure 4 is a schematic section through the apparatus taken in plane 14 in Figure 3;

Figure 5 is a schematic section through the apparatus taken in plane 16 in Figure 3;  
20

Figure 6 is a detail section corresponding to Figure 4 but showing the latching detail of the coupling that resists bending at the coupling until excessive force is applied;

Figure 6A is a close-up view of the latching detail in Figure 6;

25 Figure 7 is a view similar to Figure 1 but with the parts of the attachment responsible for bending articulation omitted to highlight the rotation mechanism part; and

Figure 8 is a cut-away view corresponding to Figure 7 and showing the construction  
30 of the clutch mechanism that rotationally couples the proximal component for axial rotation with the distal component until excessive torque is applied.

Description of the Preferred Embodiment

An overall view of the attachment apparatus is shown in Fig.1. The attachment apparatus 1 is approximately cylindrical in shape with an elongate proximal component 2 at the proximal end that attaches to the bone implant and an elongate distal component 3 at the distal end to which the prosthetic limb is attached. (In the figures these two components are also shown as cylindrical for convenience, but in practice they may not necessarily be so.)

10 The apparatus 1 has two movement accommodating mechanisms: one to allow the prosthetic limb to tilt away from axial alignment (or other fixed angle relationship) with the bone implant/residual limb when excessively forced and the other to allow twisting/ axial rotation of the prosthetic limb without twisting/ rotating the bone implant when excessive torque is applied. The twisting/ axial rotation 15 accommodating feature is suitably provided in a clutch unit 4 on the proximal component 2 while the tilting feature 5 is at the interface of the proximal component 2 and distal component 3.

An overall view of the bending/tilting feature 5 is shown in Fig.2. Starting from the 20 position when the proximal and distal components 2 and 3 are in-line the mechanism allows the distal component 3 to tilt in four directions, 7 or 8 and 9 or 10, relative to proximal component 2. By a combination of these movements distal component 3 can therefore tilt (gyrate) in any direction (e.g. 11 is a combination of 7 and 9) without being able to rotate 12 about its own axis. Although in practice it is 25 tilting of distal component 3 relative to proximal component 2 that is significant in terms of the operation of the device, for descriptive purposes it is easier to consider the movement of the components 2, 3 relative to coupling body 13 that couples the components 2, 3 together.

30 In Fig.3 the coupling body 13 of the mechanism has been omitted to show the operation of the device. Relative to the body 13 (not shown in Figure 3) the proximal element 2 is constrained to rotate/tilt only in directions 7 or 8, i.e. in the plane 14, by the curved element 15. The distal element 3 is similarly constrained to rotate/tilt only in directions 9 or 10, i.e. in the plane 16 which is orthogonal to plane 35 14, by the curved element 17.

Fig.4 is a section through the tilting mechanism in the plane 14. The centre of rotation of the proximal element 2 is located at a point 18 proximal to the mechanism. The location of point 18 is determined by the curvature of the element 15. Element 15 is constrained to move in an arc about the centre 18 by shaped slots 19 and 20 in the body of the mechanism 13.

Fig.5 is a section through the mechanism in the plane 16. In an identical manner to that for the proximal element 2, the distal element 3 is constrained to rotate about the centre of rotation 18. Because the curved element 17 is situated distal to the curved element 15 its radius of curvature is greater than that of element 15 so that the centres of rotation are coincident at point 18.

In the normal situation the elements 2 and 3 are prevented from moving relative to each other by the latching mechanism shown in Fig.6. A pin, here shown as a cylindrical element 21 which is free to slide in a hole 22 in the centre of element 2 has a conical tip which engages in a correspondingly shaped socket/depression 23 in the end of element 3. Pin 21 is kept in engagement with the depression 23 by compression of the spring 24 that biases the pin 21 forwardly.

15 20 The tilt fail-safe mechanism is activated when a force tending to tilt distal component 3 relative to proximal component 2 is sufficient to cause the tip 25 to slide up the angled side 26 of the depression 23, further compressing the spring 24. The magnitude of the force required to do this can be controlled by the amount of the compression of the spring 24. This in turn is controlled by the element 27 which is a threaded fit in the hole 22 and whose position can be changed by a screw adjustment. Once the tip 25 has been pushed out of the depression 23 it drops into a circular groove 28. Further angulation of proximal component 2 and/or distal component 3 is prevented by the physical limit imposed by the body 13.

25 30 An overall view of the clutch/axial rotation mechanism unit 4 is shown in Fig.7. It couples (partial) axial rotation 12 of the distal component 3 with the proximal component 2 until the applied torque exceeds a safe level, at which point the two are uncoupled and the proximal component rotation is then able to occur.

35 35 The construction of the clutch mechanism 4 is shown diagrammatically in Fig.8. The radially serrated face 29 on the end of distal component 3 engages with a similarly

serrated face 30 on the end of a cylindrical-shaped pin 31. Pin 31 is free to slide inside the hole 32 in the centre of proximal component 2 but is prevented from rotating relative to it by a key (not shown) which engages in longitudinal grooves in the outer wall of element 31 and in the inner wall of element 2. The faces 29 and 30

5 are held in engagement by the spring 33 exerting a distal force on element 30 while the outer case of the mechanism 34 exerts a proximal force on element 3. Compression of the spring 33 is controlled by screw adjustment of the cylindrical element 35 which is a threaded fit within the hole 32.

10 The axial rotation fail-safe mechanism triggered when a torque tending to rotate distal component 3 relative to proximal component 2 is sufficient to cause the sloping faces of the serrations of faces 29 and 30 to slide past one another, further compressing the spring 33.

Claims

1. An apparatus for attaching a prosthetic limb to the bone of a patient, the apparatus comprising:
  - 5 a proximal component to mount to a bone implant ;  
a distal component to mount to a prosthetic limb ; and  
a coupling body coupling together the proximal and distal components with freedom to articulate when, in use, a bending and/ or torsional force is applied to the prosthetic limb only when the force exceeds a threshold level whereby the force may be accommodated by articulation within the attachment apparatus.
  - 10
2. An apparatus as claimed in Claim 1, wherein the apparatus is incorporated into the bone implant component or the prosthetic limb , being in part or wholly, integrally formed or assembled with the bone implant or the limb prosthesis.
- 15
3. An apparatus as claimed in Claim 1 or Claim 2, wherein the coupling body has a clutch-like mechanism to rotationally couple the prosthetic limb to the bone implant in use but which automatically disengages, rotationally decoupling the prosthetic limb from the bone implant, when torque applied to the prosthetic limb exceeds a predetermined threshold.
- 20
4. An apparatus as claimed in Claim 3, wherein the apparatus has a resilient biasing means whereby the clutch mechanism is resiliently biased to the rotationally coupled state and whereof the biasing force applied to the clutch-like mechanism by the resilient biasing means in use determines the threshold level of torque on the prosthetic limb that will cause disengagement of the clutch.
- 25
5. An apparatus as claimed in Claim 3 or 4, wherein the apparatus has adjustment means whereby the threshold level of torque on the prosthetic limb that will cause disengagement of the clutch-like mechanism may be increased or decreased.
- 30
6. An apparatus as claimed in Claim 5 as dependent on Claim 4, wherein the adjustment means comprises a screw adjustment means that is screw-threadedly adjustable axially toward or away from the clutch-like mechanism.
- 35

7. An apparatus as claimed in any of Claims 3, 4, 5 or 6, wherein the clutch-like mechanism has opposing sets of co-operating clutch teeth whereof the teeth are substantially symmetrical in profile whereby the clutch-like mechanism may be disengaged in either rotational direction of torque, clock-wise or anti-clockwise,

5 applied to the prosthetic limb.

8. An apparatus as claimed in any of Claims 3, 4, 5, 6 or 7, wherein the clutch-like mechanism is on the proximal component but is configured to be located external to the patient's skin in use so that there will be no tearing of the patient's skin when the clutch-like mechanism disengages.

10

9. An apparatus as claimed in any preceding claim, wherein the coupling body has an automatically disengageable connector that couples together the proximal and distal components so that one is in a fixed angle relation to the other (e.g.

15 axially aligned with or at a fixed angle of incline to the axis of the other) in normal use, but with freedom to articulate away from the fixed angle relation when, in use, a bending force is applied to the prosthetic limb only when the force exceeds a threshold level.

20 10. An apparatus as claimed in any preceding claim, wherein the apparatus with disengageable connector has a resilient biasing means whereby the disengageable connector is resiliently biased to the coupled state and whereof the biasing force applied to the disengageable connector by the resilient biasing means in use determines the threshold level of bending force on the prosthetic limb that will cause

25 disengagement of the disengageable connector.

11. An apparatus as claimed in Claim 10, wherein the disengageable connector comprises a pin mounted to one of the proximal and distal components and co-operating with a socket in the other of the proximal and distal components.

30

12. An apparatus as claimed in Claim 11, wherein the pin is mounted to be movable back and forth axially of the component to which it is mounted and is biased forwardly.

35

13. An apparatus as claimed in Claim 11 or 12, wherein the pin has a pointed or domed tip and the socket is of a corresponding concave shape whereby a bending force applied to the prosthetic limb in use will cause the tip of the pin to ride outwardly up the socket wall.

5

14. An apparatus as claimed in Claim 13, wherein the shape of the tip is domed or substantially conical to facilitate disengagement of the disengageable connector whichever radial orientation the bending force is applied from.

10 15. An apparatus as claimed in any of Claims 9 to 14, wherein the disengageable connector is configured to allow gyrating articulation or universal articulation, substantially in the manner of a ball joint, when it disengages.

15 16. An apparatus as claimed in any of Claims 9 to 15, wherein the disengageable connector comprises a T-shaped formation at the end of one or both of the proximal and distal components that are adjacent each other, the head of the or each T-shaped formation being curved/ arcuate to facilitate tilting of one component relative to the other.

20 17. An apparatus as claimed in Claim 16, wherein the T-shaped formations are accommodated in the coupling body, or a further coupling body, to tilt within the coupling body.

25 18. An apparatus as claimed in Claim 17, wherein the coupling body has slots therethrough, through each of which a respective end of a head of a T-shaped formation extends and whereby the end may protrude to a greater or lesser extent as the component tilts, whereby the coupling body provides a captive articulated joint with a restricted degree of tilting freedom of movement.

30 19. An apparatus as claimed in Claim 17 or 18, wherein one T-shaped formation is oriented in the coupling body with its head substantially orthogonal to the head of the other, whereby through tilting of each relative to the other an approximately universal or gyrating articulation may be achieved.

35 20. An apparatus substantially as hereinbefore described with reference to the accompanying drawings.

**Abstract****Prosthetic Limb Attachment**

5

The present invention provides an apparatus for attaching a prosthetic limb to the bone of a patient, the apparatus comprising: a proximal component to mount to a bone implant ; a distal component to mount to a prosthetic limb ; and a coupling body coupling together the proximal and distal components with freedom to 10 articulate when, in use, a bending and/ or torsional force is applied to the prosthetic limb only when the force exceeds a threshold level whereby the force may be accommodated by articulation within the attachment apparatus. The attachment apparatus thus functions as a fail-safe articulation mechanism protecting the bone of the patient.

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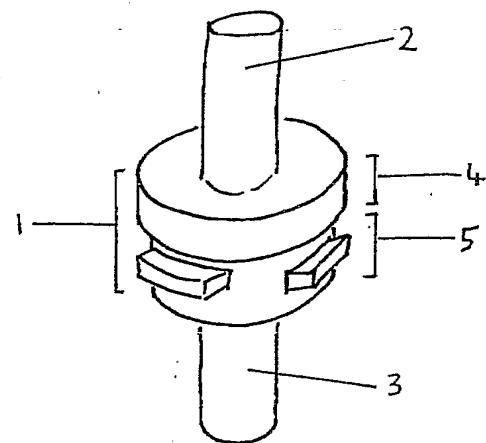


FIG. 1

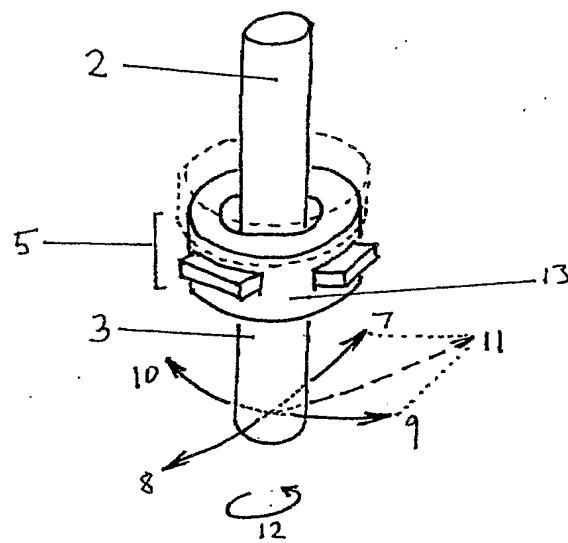


FIG. 2

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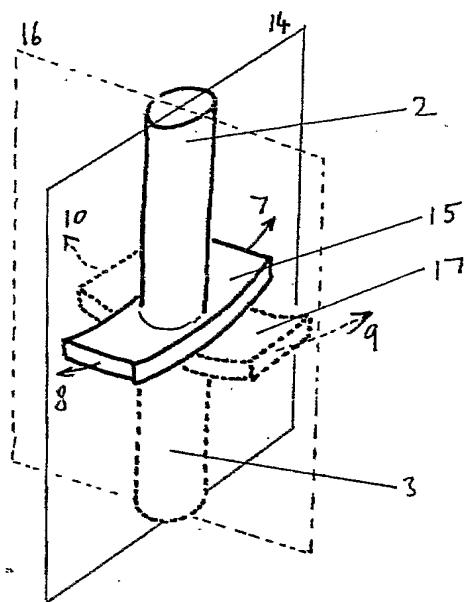


FIG. 3

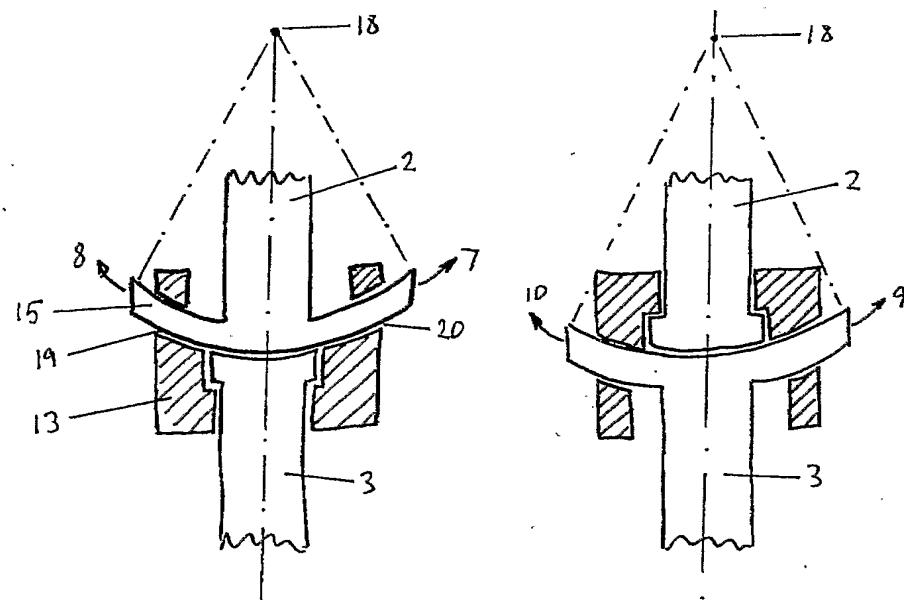


FIG. 4

FIG. 5

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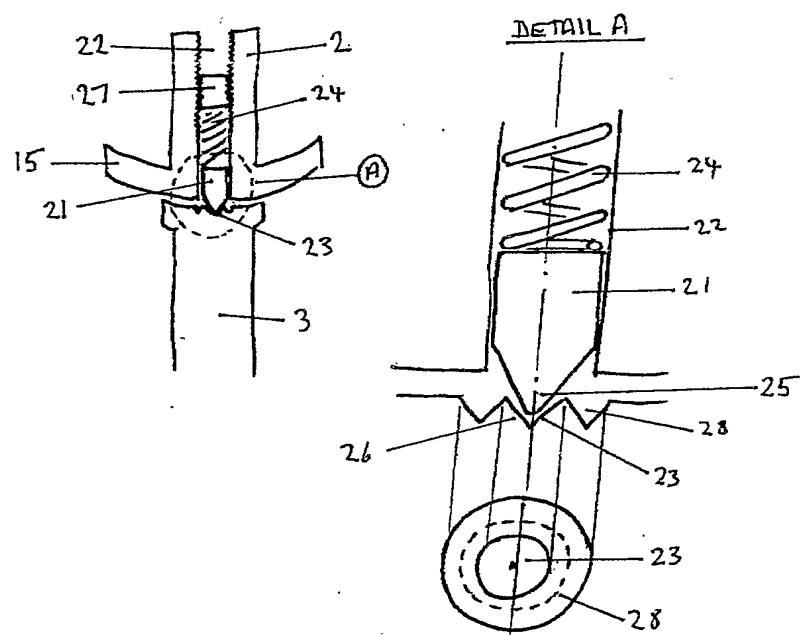


FIG. 6

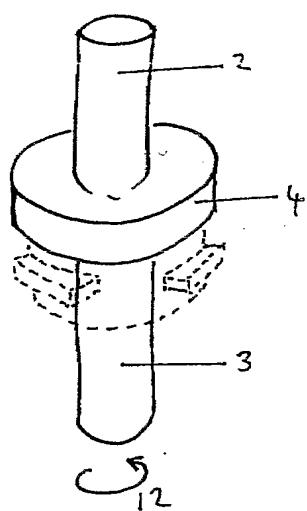


FIG. 7

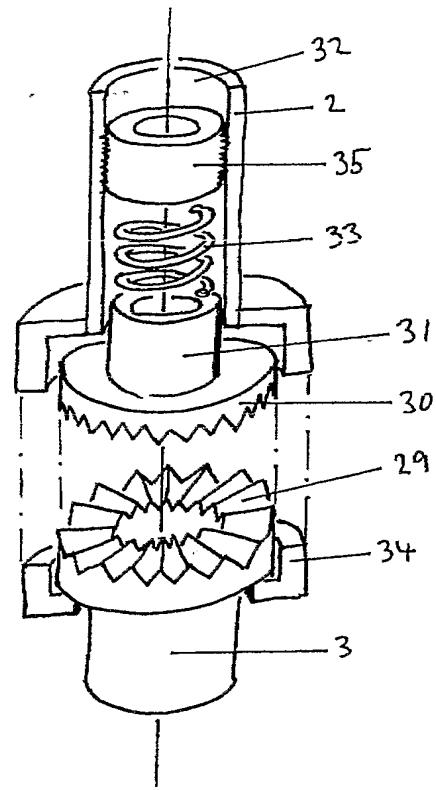


FIG. 8



